INDOOR AIR QUALITY REASSESSMENT

Lynnhurst Elementary School
443 Walnut Street
Saugus, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
June 2006

Background/Introduction

At the request of parents and the Town of Saugus Health Department, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality concerns specifically mold and odors at the Lynnhurst Elementary School in Saugus, Massachusetts.

The LES was originally visited in November 2002 by Cory Holmes, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program; a report was issued that detailed conditions found in the building at the time of the assessment (MDPH, 2003) and recommendations for improvement. . On April 7, 2006, Mr. Holmes returned to the LES to conduct an air quality assessment and observe progress/efforts undertaken by the Saugus Building Department, Saugus School Department, LES maintenance staff, administration and faculty to improve indoor air quality within the building.

Actions on MDPH Recommendations

A summary of actions taken on previous recommendations is included as Appendix A (MDPH, 2003).

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were conducted with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. Air tests for airborne particulate matter with a diameter less than 2.5 micrometers were taken with the

TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using an Hnu, Model 102 Snap-on Photo Ionization Detector (PID). MDPH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

This school houses grades K-5 and has a student population of approximately 260 and a staff of approximately 20. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in eight of nineteen areas surveyed (Table 1). These results indicate poor air exchange in several areas, mainly due to the intermittent operation of the mechanical ventilation system, which is explained in detail in Appendix A. It is also important to note that several classrooms were sparsely populated and/or had open windows during the assessment, which can reduce carbon dioxide levels. It is also important to note that univents in some classrooms were deactivated by occupants.

Without a continuous source of fresh outside air indoor environmental pollutants can build-up and lead to indoor air quality/comfort complaints. Please note that there are a number of rooms (6, 7, 8, 10, 12) that had carbon dioxide above 1,500 ppm. In one room (8), the carbon dioxide level exceeded the Occupational Safety and Health

Administration (OSHA) standard for carbon dioxide (5,000 ppm), which would be unacceptable for exposure to a healthy, working adult if exposed over an eight hour day, forty-hour work week. Please note that OSHA standards ***are not*** acceptable exposure levels of carbon dioxide for children. Each of these rooms had the following characteristics which likely contributed to the excessive carbon dioxide levels.

- Each area had a population greater than twenty individuals.
- Univents in the areas were deactivated,
- Each room had all windows closed.
- The building lacked of airflow through drafty window/door sashes and frames (called air infiltration) due to the sealing of the building envelope by the Saugus Building Department to prevent water penetration and drafts.

At the conclusion of the reassessment MDPH staff strongly recommended to Principal

John Macero, that classroom windows be used to supplement univents to introduce fresh outside air. This was also recommended in subsequent communication with Sharon McCabe, Director of the Saugus Board of Health and Ralph Materissi, Building Maintenance Director, Town of Saugus.

The design of the mechanical exhaust ventilation system in classrooms is such that classroom air must be pulled beneath the doors of coat closets through a grill located in the top of the coat closets, powered by rooftop motors. Air is drawn into the coat closet from the classroom via undercut closet doors. The location of these closet vents allows them to be blocked by stored materials. Mr. Macero and Mr. Materissi, discussed the installation of a ducted grill on the face of the coat closet (Picture 1), which would draw exhaust directly from the classroom. This modification in combination with the continuous operation of univents and/or the opening of classroom windows should enhance air circulation.

The main office, library, teacher's lounge, and the resource room (next to the library) had louvered ceiling vents (Picture 2). However no airflow (neither supply nor exhaust) could be detected from these vents, making it difficult to determine their function. The Nurse's office does not have a means of mechanical ventilation nor openable windows.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The OSHA standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix B.

Temperature readings ranged from 72 ^{o} F to 75 ^{o} F, which were within the MDPH comfort guidelines during the assessment. The MDPH recommends that indoor air temperatures be maintained in a range between 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. A number of temperature control/comfort complaints were still expressed in several areas, primarily heat issues. These complaints may be attributed to the deactivation and intermittent operation of univents. The univents are designed to mix fresh outdoor air with air from inside the room. Without the draw of outdoor air, return air is not tempered and is repeatedly heated, leading to high temperatures. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Relative humidity measurements ranged from 27 to 43 percent, which were below the MDPH recommended comfort range in most of the areas surveyed. The MDPH recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Other Concerns

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, CEH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. On the day of assessment, outdoor carbon monoxide concentrations were non-detect (ND). A slight carbon monoxide reading of 1-2 ppm was measured in the kitchen, cafeteria and the nurse's office, which is located between the boiler room and kitchen (Table 1). These measurable levels can be attributed to the use of gas-fired cooking appliances during lunch preparation and the lack of adequate ventilation. In addition, the kitchen is open to the main hallway and the door between the nurses office and kitchen is routinely propped open (Picture 3). MDPH staff also inspected the boiler room for potential sources/pathways for combustion products to migrate into adjacent areas. Open utility holes were observed in the common wall between the boiler room and nurse's office (Picture 4). Carbon monoxide levels in the remainder of the school were ND (Table 1). CEH staff were informed, in subsequent conversation with Mr. Materissi, that an additional rooftop exhaust motor was installed in the kitchen to remove combustion products and cooking odors.

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 19 $\mu g/m^3$ (Table 1). PM2.5 levels measured in occupied areas of the school ranged from 14 to 35 $\mu g/m^3$, which were below the NAAQS of 65 $\mu g/m^3$ (Table 1). Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operation. Sources of indoor airborne particulate may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices, operating an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Indoor TVOC concentrations were ND (Table 1). An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were also ND.

Indoor air concentrations can be greatly impacted by the use of TVOC-containing products. In an effort to identify materials that can potentially increase indoor TVOC concentrations, MDPH staff examined classrooms for products containing these respiratory irritants. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 5). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and cause TVOCs to off-gas. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix C (NIOSH, 1998).

Finally, subsequent to this most recent MDPH assessment, concerns of asbestos exposure were expressed to the Massachusetts Division of Occupational Safety. In 1986, the Asbestos Hazard Emergency Response Act [AHERA; Asbestos Containing Materials (ACM) in Schools, 40 CFR Part 763, Subpart E] was signed into law. AHERA requires the inspection of schools for asbestos containing building materials (location, type, and condition) and preparation of management plans which recommend the best way to reduce asbestos hazards (USEPA, 1986). Under AHERA facilities are required to be inspected for asbestos containing material (visually every six months and comprehensively every three years by an accredited inspector). The Massachusetts Division of Occupational Safety (DOS) provides technical assistance to schools in Massachusetts by reviewing management plans and conducting on-site assessments for compliance with AHERA. In addition, DOS regulates asbestos abatement in schools and other buildings through its regulations, licensing, site visits, and enforcement.

According to documents forwarded to MDPH by the Saugus School Department, friable ACM was found in the form of uncovered insulation in inaccessible areas above ceilings and damaged pipe insulation in the kitchen by their environmental consultant, FLI, Inc. FLI recommended that the damaged/exposed material be sealed with an encapsulant or removed (FLI, 2003). Repair work was performed at the LES in July of 2005. Background samples were taken and analyzed during the work. All samples were below the Massachusetts airborne fiber limit of 0.01 fibers per cubic centimeter (f/cc) for post abatement reoccupancy (FLI, 2005). It is our understanding that DOS is now involved with assessing any asbestos management concerns associated with the school.

Conclusions/Recommendations

Saugus School officials, working in conjunction with the Saugus Building Department, private contractors, LES administration, faculty members and school maintenance staff, have made some improvements to building conditions noted in the previous MDPH report (MDPH, 2003) by implementing the majority of MDPH's recommendations. As indicated in Appendix A, several of these recommendations need further action. In view of the findings at the time of this visit, the following additional recommendations are made to further improve indoor air quality:

1. Improve air exchange in certain classrooms. An increase in the percentage of fresh air supply is paramount. Contact an HVAC engineering firm to determine if univents can be modified to run continuously to provide an ongoing source of fresh air.
2. Consider relocating the nurse's office. If not feasible, make provisions to install mechanical ventilation or openable windows to provide air exchange.
3. Continue with plans to install ducted exhaust grills to the face of coat closets to improve air exchange.
4. Open windows to supplement the introduction of outside air from univents and improve air exchange/comfort in classrooms. Care should be taken to ensure windows are properly closed at night and weekends during the heating season to avoid the freezing of pipes and potential flooding.

5. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters.
6. Continue with window replacement project.
7. Seal utility holes in boiler room and replace missing ceiling tiles in other areas of the building to prevent the migration of odors and/or particulates.
8. Store cleaning products properly and out of reach of students.
9. Change filters for air-handling equipment (e.g., univents, AHUs and ACs) as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit.
10. Consider discontinuing the use of tennis balls on furniture and replacing tennis balls with alternative "glides". Refer to Picture 6 for an example.
11. Keep all doors to the kitchen and nurses office shut.
12. Contact an HVAC engineering firm to inspect the local exhaust hood in the kitchen for proper function and develop a preventative maintenance program for this equipment.

13. Continue to maintain and implement AHERA plan in accordance with state and federal regulations.
14. If the DOS effort identifies an area where asbestos may offer exposure opportunities, MDPH will, at the request of local health officials, further evaluate health concerns.
15. Consider adopting the US EPA (2000b) document, "Tools for Schools", to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.
16. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website: http://mass.gov/dph/indoor_air.

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Picture 1

Arrow Indicates Recommended Location on Front Face of Coat Closet for Ducted Exhaust Grill

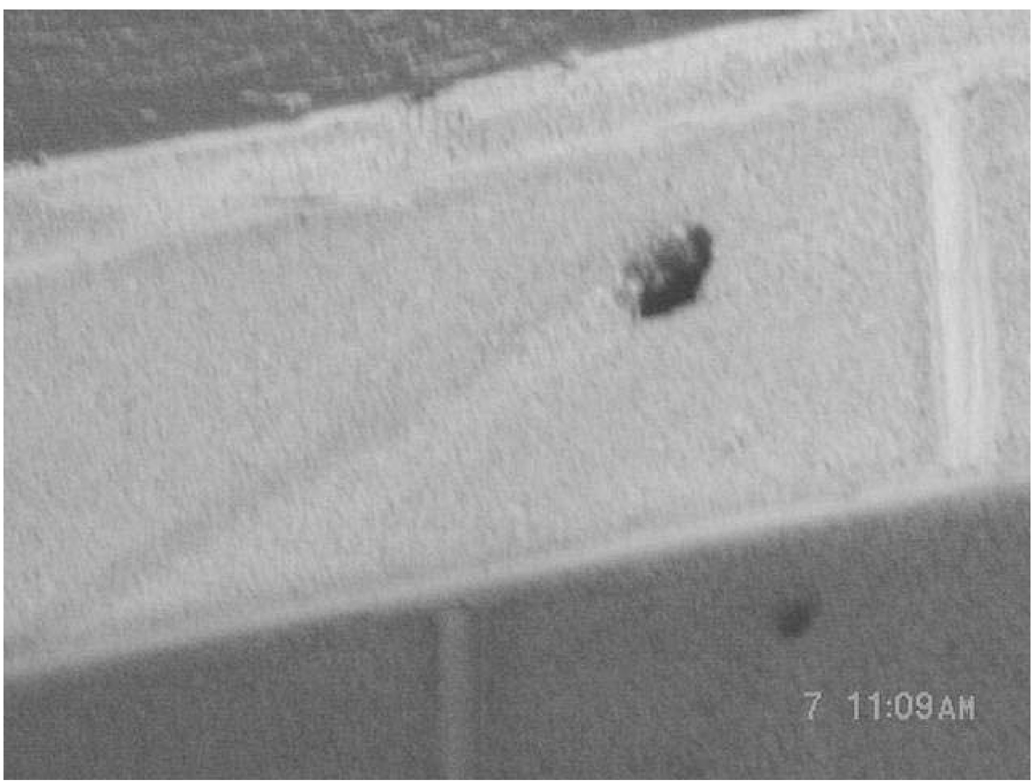
Picture 2

Ceiling Vent in Library

Picture 3

Kitchen Door to Nurse's Office Propped Open during Lunch Prep

Picture 4

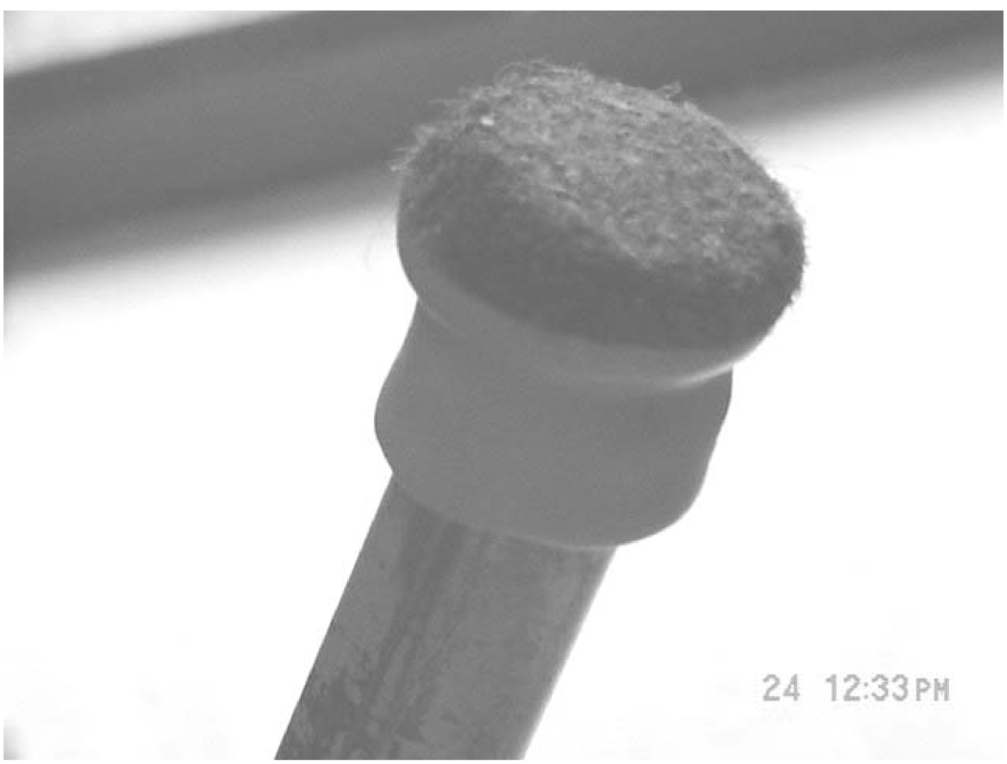


Open Utility Holes in Common Wall between Boiler Room and Nurse's Office

Picture 5

Tennis Balls on Desk Legs in Classroom

Picture 6



“Glides” for Chair Legs that can be used as an Alternative to Tennis Balls

Lynnhurst School

443 Walnut St, Saugus, MA 01906

Indoor Air Results

Date: 04/07/2006

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Background		59	35	329	ND	ND	19	N			Mostly sunny, winds SW 15-20 mph.
1	22	75	30	701	ND	ND	14	Y # open: 1 # total: 4	Y univent	Y closet	Hallway DO, DEM.
2	19	73	31	495	ND	ND	16	Y # open: 0 # total: 3	Y univent (off)	Y closet	
3	22	74	27	575	ND	ND	16	Y # open: 2 # total: 4	Y univent (off)	Y closet	breach sink/counter, cleaners.
4	22	74	27	532	ND	ND	16	Y # open: 2 # total: 4	Y univent	Y closet	breach sink/counter, #MT/AT: 1, DEM.
5	29	74	29	677	ND	ND	16	Y # open: 2 # total: 4	Y univent	Y closet	#WD-CT: 10, breach sink/counter, plants.
6	28	74	34	2069	ND	ND	22	Y # open: 0 # total: 4	Y univent (off)	Y closet	#WD-CT: 20, breach sink/counter, cleaners.

ppm = parts per million
µg/m3 = micrograms per cubic meter
AD = air deodorizer
AP = air purifier
aqua. = aquarium
AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Lynnhurst School **Indoor Air Results**

443 Walnut St, Saugus, MA 01906 **Table 1** **Date: 04/07/2006**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
7	32	73	39	3872	ND	ND	35	Y # open: 0 # total: 3	Y univent (off)	Y closet	TB, cleaners.
8	29	72	40	5130	ND	ND	29	Y # open: 0 # total: 4	Y univent (off)	Y closet	breach sink/counter, DEM, TB, ceiling fan.
9	1	74	30	1045	ND	ND	19	Y # open: 0 # total: 4	Y univent (off) plant(s)	Y closet	Hallway DO, cleaners, plants, 23 occupants gone 40 minutes.
10	24	75	43	2276	ND	ND	22	Y # open: 0 # total: 4	Y univent (off)	Y closet	breach sink/counter, cleaners, ceiling fan, water damaged paper under sink.
11	22	73	33	1384	ND	ND	21	Y # open: 0 # total: 0	Y univent	Y closet	cleaners, plants.
12	25	73	33	1584	ND	ND	21	Y # open: 0 # total: 3	Y univent (off)	Y closet	#WD-CT: 9, DEM, TB, cleaners, plants.

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Lynnhurst School

443 Walnut St, Saugus, MA 01906

Table 1

Indoor Air Results

Date: 04/07/2006

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Teacher's Lounge	2	73	30	894	ND	ND	22	N	Y ceiling	Y wall	exhaust in bathroom-door undercut.
kitchen	2	74	28	440	2	ND	16	N		Y ceiling	Hallway DO, Inter-room DO, door open into nurse's office, gas ovens operating-lunch prep.
cafeteria	125	73	30	779	1	ND	22	N	Y wall	Y wall	Hallway DO, Inter-room DO, efflourescence brick.
main hallway	0	ND	ND	ND	ND	ND	ND	N			#WD-CT: 3.
Main Office	2	73	30	455	ND	ND	23	N	Y ceiling (off)	N	Hallway DO, PC.
Library	0	74	28	476	ND	ND	14	N	Y ceiling (off)	N	Hallway DO,
Resource Room (next to library)	0	74	29	584	ND	ND	17	N	Y ceiling (off)	N	Hallway DO, DEM.

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Relative Humidity: 40 - 60%

Lynnhurst School | **Indoor Air Results**

443 Walnut St, Saugus, MA 01906 | **Date: 04/07/2006**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Nurse	4	74	28	511	2	ND	26	N	N	N	Hallway DO, Inter-room DO, door open into kitchen, kitchen odors, nurses office located in small area between boiler room and kitchen, no windows/no mech vent .

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